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RADIOACTIVE DECONTAMINATION PROPERTIES OF LABORATORY SURFACES

II. Paints, Plastics and Floor Materials

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ABSTRACT

The susceptibility of various paints, plastics, and floor materials to contamination and their subsequent ease of decontamination have been determined by simple empirical tests. The probable usefulness of these materials in Radioactive Laboratories and attendant facilities are further indicated by chemical resistance tests with common laboratory reagents.

RADIOACTIVE DECONTAMINATION PROPERTIES OF LABORATORY SURFACES

II. PAINTS, PLASTICS AND FLOOR MATERIALS[1]

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Many materials which are commonly used in radiochemical laboratories have proved difficult, if not practically impossible, to clean once they have become contaminated with a radioactive element. This has led to the general conclusion that radioactive decontamination and surface erosion are practically synonymous. Therefore, considerable emphasis has been placed on a search for materials which are resistant to chemical corrosion and abrasion, with much of the emphasis being placed on properties permitting replacement of sections which are highly contaminated.

Complete reliance on the use of expendable materials for permanent fixtures is less satisfactory in many instances than the use of more permanent surfaces if these can be satisfactorily cleaned by ordinary reagent techniques. Also, many persons in relatively small institutions do most of their work at activity levels low enough to permit proper maintenance by the cheaper cleaning procedures. For these reasons, a systematic study of the problems involved in reagent cleaning has been initiated at Oak Ridge National Laboratory in collaboration with the Isotopes Division of the Atomic Energy Commission.

Extensive scouting experiments with several materials and reagents led to the development of simple, empirical tests by which the susceptibility of different materials to contamination, and their subsequent ease of decontamination could be compared under controlled conditions (1). This paper reports the results obtained by the standard test on different resins (paints and strip coats), plastics and flooring materials.[5]

Since these materials are used to coat either porous or corrodible items, the best surfaces would be built up as follows:

1) First Layer - Seal Coat. This coat must penetrate the porous material to some depth (several mm. on concrete or wood) and fill all the pores with a homogeneous, chemically resistant body.

2) Second Layer - Permanent Surface Coat. This is preferably a homogeneous extension of the seal coat. It should be resistant to those conditions to which it is destined to be exposed, and should have a low adsorption value for the radioelements of interest.

3) Third Layer - Final Surface Coat. This may be varied to suit conditions. In addition to the requisite chemical and physical properties, it should have a low susceptibility to contamination, and a large decontamination index[6] for all the radioelements of interest, and the most important contaminating conditions encountered. In the case of flooring material, an exterior wax finish is often used. These data are of a preliminary nature to the extent that a wider range of elements and contaminating conditions must be explored before a full evaluation can be made.

MATERIALS AND METHODS

PREPARATION OF THE COATINGS

The various coatings were applied to $2\frac{1}{2} \times 2\frac{1}{2}$-inch plaques as nearly as possible in the manner and to the type of material recommended by the manufacturer. They were cured in a dust-free atmosphere with adequate ventilation for the prescribed time or longer. Those which required heat curing were baked under the conditions prescribed by the manufacturer.

The finished plaques were stored individually and examined carefully before use. Only those which presented a smooth, nonporous appearance were selected in an effort to obtain data under the best possible conditions.

Some of the materials were submitted in sheet forms. Plaques of the proper size were cut from these sheets, and the edges rounded to minimize adsorption. These materials are indicated by an asterisk in tables.

DECONTAMINATING TESTS

Carrier-free[7] solutions of $H_3P^{32}O_4$, Ba^{140}, and I^{131} were used in the form and concentrations provided by the Operations Division of Oak Ridge National Laboratory (2). Approximately 100 - 200 μc of activity was applied as contamination in each case.

The methods for testing the succeptibility of a surface to contamination and its subsequent ease of decontamination with various reagents have been described in a previous paper (1). The susceptibility test measures the apparent adsorption of the radioelement by the surface when a small drop is allowed to stand in contact with the surface for an hour. The decontamination test measures the total amount of contamination that may be removed at the end of the second decontamination step when a small drop of radioactive solution is dried on the surface under controlled conditions and then removed, first by the standard reagent alone, and then by scrubbing.

The standard reagents used for this work are:

For P^{32} : $3N\ HNO_3 - 3N\ H_3PO_4$

For Ba^{140}: $6N\ HNO_3$

For I^{131} : 56% HI

A beginning has been made toward the development of less corrosive reagents, such as detergents, which would be the ones used in practice. These would be expected to vary in efficiency from one material to another. The detergents used were prepared in accordance with the specifications of the manufacturer. A 1% solution was used except as otherwise specified.

CORROSION TESTS

The various coatings were also applied to rounded rods 3/8-inch diameter by 5 inches long of soft wood or aluminum. These were immersed at room temperature for periods of one week in 3M solutions of HNO_3, HCl, H_2SO_4, NaOH and in hexone (selected as a "typical" organic solvent of the ketone type).

Failure of the coating was indicated (1) if the reagent became badly discolored, (2) if the coating became soft or (3) if "bleed through" was indicated by discoloration of the test rod at a level of 0.5 cm above the immersion level.

The coatings were rated as follows:

E - Passed all tests

S - Satisfactory for HCl, HNO_3, H_2SO_4, NaOH

AS - Satisfactory for acids, failed with NaOH

AS** - Failed with NaOH, and only one acid

S** - Satisfactory for NaOH, failed with one acid

F - Failed with NaOH and two acids

These symbols appear beneath the name of the various materials which are listed alphabetically under the manufacturer's name in Tables I and II. This classification draws not only on the data obtained in our laboratory, but also from data obtained by us under other conditions, and on data obtained by others.[8] Specific corrosion data obtained in our laboratory is listed in Table V. There was insufficient information on some materials to permit such classification and these have been left blank.

The purpose of this investigation is to explore the extent to which protective coatings can be used with ordinary structural materials such as wood, transite, concrete, etc., so that reagent cleaning procedures can be used for their maintenance. A serious attempt has been made to develop the information in such a way that it will contribute to the ultimate construction of standard tables so that decontamination properties may be included among the physical and chemical properties of a product.

RESULTS AND DISCUSSION

CHEMICAL RESISTANCE TESTS

Previous studies (1) have shown that when a cleaning solvent is applied to a surface contaminated with a radionuclide, practically all of the contaminant that can be removed in a reasonable time is removed very rapidly. The very tenacious retention of the residual activity that is so well known to workers in the field has been shown to arise in part from a slow rate of exchange between the surface and the solvent. The removal of this slowly exchanging fraction, as well as of atoms irreversibly attached to the surface, can be accomplished only by a process of surface erosion, preferably by the removal of successive "monolayers."

Therefore, it is desirable to find a solvent which may be used as the final step in the cleaning process which would attack the surface very slowly and yet not soften it significantly. This characteristic, as well as general chemical resistance, is important in considering the results of the corrosion tests.

The following discussion concerns only the protective coatings. Fluorothene, polythene, Duralon #35 and Monsanto research sample J-653, which is a strip coat, withstood all of the corrosion tests. The baked Shell enamel and Unichrome B-124-1 successfully withstood the hexone but failed in the presence of the alkali.

The Devon Resin K 5925 withstood the hexone for 24 hours and all of the

TABLE I

MATERIAL DECONTAMINATION AND SUSCEPTIBILITY TESTS

Material and Manufacturer (Corrosion Rating)[11]	Isotope	Gross Average	Spill Index	% Adsorbed in 1 hr.	DI_s	Step 1 DI	Step 2 DI
615 Rubalt (Green) Alfred Hague & Co. (F)	P^{32}	4	4.9	.09	3.8	2.7	1.1
	Ba^{140}		5.0	.04	3.6	3.3	.3
	I^{131}		3.3	.02	1.6	1.4	.2
Amercoat #55 Amer. Pipe & Constr. Co. (S)	P^{32}	6	7.3	.01	5.3	3.2	2.1
	Ba^{140}		7.2	.01	5.2	4.1	1.1
	I^{131}		3.3	.01	1.3	1.2	.1
Amercoat #44 Amer. Pipe & Constr. Co. (S)	P^{32}	6	7.5	.01	5.5	3.0	2.5
	Ba^{140}		6.8	.01	4.8	3.6	1.2
	I^{131}		3.0	.02	1.3	1.3	.03
Amercoat #31 Amer. Pipe & Constr. Co. (S)	P^{32}	5	6.4	.05	5.1	3.4	1.7
	Ba^{140}		6.0	.03	4.5	4.0	.5
	I^{131}		3.3	.02	1.6	1.6	.02
Asphalt-Tile Flooring* Armstrong Cork Company (F)	P^{32}	2	1.7	5.2	2.4	2.1	.3
	Ba^{140}		1.9	14.2	2.9	2.1	.8
	I^{131}		1.5	16.5	2.8	2.8	.02
Duranite H (White) Atlas Powder Company (AS**)	P^{32}	6	6.8	.005	4.5	3.4	1.1
	Ba^{140}		5.7	.02	4.0	2.4	1.6
	I^{131}		4.1	.07	1.9	1.7	.2
20BK Varnish Barrett Varnish Company (A.S)	P^{32}	6	8.0	.005	5.7	3.3	2.4
	Ba^{140}		7.1	.01	5.1	4.1	1.0
	I^{131}		3.3	.008	1.2	1.1	.1
Gray M-101 Bisonite Company (S)	P^{32}	5	5.6	.02	3.9	3.1	.8
	Ba^{140}		6.8	.005	4.5	3.5	1.0
	I^{131}		4.0	.02	2.3	2.2	.1
Fluorothene*-Flame Sprayed onto Aluminum Carbon & Carbide K-25 (E)	P^{32}	4	5.7	.1	4.7	3.8	.9
	Ba^{140}		4.7	.5	4.4	2.9	1.5
	I^{131}		2.0	1.0	2.0	1.5	.5
Plastic Coating 541 (Green) Corrosite Corp. (A.S.**)	P^{32}	6	7.2	.01	5.2	3.7	1.5
	Ba^{140}		6.8	.01	4.8	4.1	.7
	I^{131}		2.8	.006	1.5	1.5	.03
Plastic Coating (Gray) Corrosite Corporation (S)	P^{32}	5	5.6	.02	3.9	3.2	.7
	Ba^{140}		5.4	.03	3.9	3.7	.2
	I^{131}		3.5	.01	1.5	1.4	.1

Material and Manufacturer (Corrosion Rating)	Isotope	Gross Average	Spill Index	% Adsorbed in 1 hr.	DI_s	Step 1 DI	Step 2 DI
Plastic Coating #8228	P^{32}		4.1	.2	3.4	3.0	.4
Corrosite Corporation	Ba^{140}	4	5.1	.2	4.4	3.9	.5
(S)	I^{131}		3.1	.02	1.4	1.4	.1
Plastic Coating (Aluminum)	P^{32}		3.6	.5	3.3	2.7	.6
Corrosite Corporation	Ba^{140}	4	4.8	.3	4.3	3.2	1.1
(F)	I^{131}		3.1	.02	1.4	1.3	.1
Devon Resin K-5925 (Clear)	P^{32}		4.1	.2	3.4	2.8	.6
Devoe and Reynolds Company	Ba^{140}	4	5.5	.02	3.8	3.5	.3
(S)	I^{131}		2.6	.2	1.9	1.8	.1
Lucite*	P^{32}		9.4	.005	7.1	3.6	3.5
DuPont Corporation	Ba^{140}	7	5.2	.3	4.7	4.4	.3
(S)	I^{131}		5.6	.002	2.9	2.6	.3
Polythene*	P^{32}		7.4	.009	5.3	3.8	1.5
DuPont Corporation	Ba^{140}	6	6.1	.9	6.0	4.0	2.0
(E)	I^{131}		4.7	.03	3.2	2.8	.4
Shell Enamel (Baked)	P^{32}		7.0	.008	4.9	4.0	.9
DuPont Corporation	Ba^{140}	7	9.1	.004	6.7	4.0	2.7
(AS)	I^{131}		4.0	.01	2.0	1.9	.1
Shellstone*	P^{32}		5.3	.004	2.9	2.5	.4
E. H. Sheldon & Co.	Ba^{140}	3	1.2	21.60	2.5	2.3	.2
(E)	I^{131}		1.6	.07	.4	.3	.1
Supernite Varnish	P^{32}		5.9	.01	3.9	2.5	1.4
The Garland Company	Ba^{140}	5	6.0	.01	4.0	3.8	.2
(A.S.)	I^{131}		2.8	.02	1.1	1.0	.1
Acanal (Gray)	P^{32}		4.7	.03	3.2	3.1	.1
The Garland Company	Ba^{140}	4	5.5	.08	4.4	3.0	1.4
(S)	I^{131}		3.1	.05	1.8	1.7	.1
Acanal (White)	P^{32}		3.1	.4	2.7	2.5	.2
The Garland Company	Ba^{140}	3	3.9	.3	3.4	3.2	.2
(S)	I^{131}		3.2	.02	1.5	1.3	.2
Textolite*	P^{32}		5.0	.07	3.8	3.2	.6
General Electric Co.	Ba^{140}	4	4.9	.05	3.6	3.4	.2
(E)	I^{131}		3.0	.03	1.5	1.2	.3
Pli-Namel 815 Concrete	P^{32}		5.7	.04	4.3	2.7	1.6
The Glidden Co. (Gray	Ba^{140}	5	6.2	.02	4.5	4.0	.5
(A.S.)	I^{131}		3.4	.01	1.4	1.2	.2
Black Chem. Resistant #1	P^{32}		5.8	.03	4.3	3.6	.7
The Glidden Company	Ba^{140}	4	4.8	.07	3.6	3.4	.2
(A.S.)	I^{131}		2.3	.08	1.2	1.1	.1

Material and Manufacturer (Corrosion Rating)	Isotope	Gross Average	Spill Index	% Adsorbed in 1 hr.	DI_s	Step 1 DI	Step 2 DI
Black Chem. Resistant #2	P^{32}		3.2	.4	2.8	2.2	.6
The Glidden Company	Ba^{140}	3	3.4	.2	2.7	2.2	.5
(F)	I^{131}		1.0	.4	.6	.5	.1
Black Chem. Resistant #3	P^{32}		6.0	.04	4.6	3.4	1.2
The Glidden Company	Ba^{140}	4	3.7	.80	3.6	3.1	.5
(F)	I^{131}		2.9	.08	1.8	1.3	.5
Methacrylate (White)	P^{32}		4.1	.20	3.4	3.1	.3
The Glidden Company	Ba^{140}	4	3.9	.04	2.5	2.5	.04
(S)	I^{131}		4.1	.01	2.1	1.9	.2
Alkyd (White)	P^{32}		5.7	.01	3.7	3.2	.5
The Glidden Company	Ba^{140}	4	4.6	.01	2.6	2.6	.03
(A.S.**)	I^{131}		2.9	.03	1.4	1.0	.4
Vinyl Paint (White)	P^{32}		5.1	.02	3.4	2.6	.8
The Glidden Company	Ba^{140}	4	4.0	.03	2.5	2.4	.1
(S)	I^{131}		3.8	.01	1.8	1.7	.1
Rubber Haint (White)	P^{32}		5.9	.01	3.9	2.9	1.0
The Glidden Company	Ba^{140}	5	4.7	.03	3.2	2.9	.3
(S**)	I^{131}		3.2	.02	1.5	1.4	.1
Chlorinated Rubber (Gray)	P^{32}		4.0	.50	3.7	3.2	.5
The Glidden Company	Ba^{140}	4	5.4	.01	3.4	3.1	.3
(A.S.)	I^{131}		3.2	.02	1.4	1.3	.1
Goodyear Vinyl Style 3511*	P^{32}		2.9	5.30	3.4	3.3	.1
Goodyear Rubber Company	Ba^{140}	2	1.6	5.60	2.4	2.0	.4
(S)	I^{131}		2.2	.20	1.5	1.4	.1
J-241-B (Gray)	P^{32}		5.6	.04	4.2	3.1	1.1
The Gordon Lacy Company	Ba^{140}	5	5.9	.02	4.2	3.9	.3
(A.S.**)	I^{131}		3.4	.02	1.7	1.7	.03
J-211-E (White)	P^{32}		4.4	.04	3.0	2.7	.3
The Gordon Lacy Company	Ba^{140}	4	5.3	.02	3.6	3.1	.5
(S)	I^{131}		3.2	.008	1.1	1.1	.03
A-248-B (Clear)	P^{32}		7.1	.007	4.9	3.5	1.4
The Gordon Lacy Company	Ba^{140}	6	6.4	.02	4.7	4.0	.7
(S)	I^{131}		3.7	.003	1.2	1.2	.03
J-220-F	P^{32}		5.9	.02	4.2	3.0	1.2
The Gordon Lacy Company	Ba^{140}	5	5.4	.03	3.9	2.3	1.6
(S)	I^{131}		2.8	.005	.5	.4	.1
A-89-A (Black)	P^{32}		6.3	.04	4.9	3.1	1.8
The Gordon Lacy Company	Ba^{140}	5	5.8	.01	3.8	3.2	.6
(S)	I^{131}		3.3	.02	1.6	1.5	.1

Material and Manufacturer (Corrosion Rating)	Isotope	Gross Average	Spill Index	% Adsorbed in 1 hr.	DI_s	Step 1 DI	Step 2 DI
Silicone-583 (Heat Dried) Interchemical Corp. (AS)	P^{32}		9.2	.002	6.5	4.5	2.0
	Ba^{140}	8	8.9	.002	6.2	5.1	1.1
	I^{131}		5.2	.003	2.7	2.6	.1
Silicone-575 (Heat Dried) Interchemical Corp. (AS)	P^{32}		8.0	.006	5.8	4.9	.9
	Ba^{140}	7	7.3	.003	4.8	4.7	.1
	I^{131}		5.1	.006	2.9	2.8	.1
Silicone-60.9 (Heat Dried) Interchemical Corp. (F)	P^{32}		7.0	.01	5.0	4.2	.8
	Ba^{140}	6	6.2	.005	3.9	3.4	.5
	I^{131}		4.9	.007	2.7	2.6	.1
Rigortex 2202 (Clear) Inertol Company (A.S.**)	P^{32}		7.0	.01	5.0	3.5	1.5
	Ba^{140}	6	6.5	.02	4.8	3.9	.9
	I^{131}		3.9	.01	1.9	1.8	.1
LC-600 (Clear) Lithgow Corporation (S**)	P^{32}		3.3	.3	2.8	2.3	.5
	Ba^{140}	3	3.7	.05	2.4	2.3	.1
	I^{131}		2.3	.06	1.1	1.0	.1
Cotoid (Gray) Lithgow Corporation (F)	P^{32}		4.4	.2	3.7	3.1	.6
	Ba^{140}	5	5.9	.03	4.4	3.5	.9
	I^{131}		3.9	.01	1.9	1.8	.1
Shiller (White Enamel #3) M. Shiller Company (AS)	P^{32}		4.4	.05	3.1	3.0	.1
	Ba^{140}	5	5.6	.06	4.4	3.9	.5
	I^{131}		3.5	.01	1.5	1.4	.1
Coprene (Clear) Maas and Waldstein (A.S)	P^{32}		6.2	.03	4.7	3.2	1.5
	Ba^{140}	6	6.7	.1	5.7	3.8	1.9
	I^{131}		3.7	.02	2.0	1.8	.2
Permanite FAH* Maurice A. Knight Co. (F)	P^{32}		5.2	.1	4.2	3.5	.7
	Ba^{140}	4	3.3	.15	3.6	3.3	.3
	I^{131}		2.5	.2	1.8	1.5	.3
Pyroflex* (On Permanite) Maurice A. Knight Co. (S)	P^{32}		4.7	.6	4.5	3.8	.7
	Ba^{140}	4	4.4	1.8	4.7	3.6	1.1
	I^{131}		3.3	.04	1.9	1.9	.04
Pyroflex Lacquer (White) Maurice A. Knight Co. (S)	P^{32}		6.3	.02	4.6	3.4	1.2
	Ba^{140}	5	5.5	.06	4.3	2.6	1.7
	I^{131}		4.1	.005	1.8	1.7	.1
Pyroflex Lacquer (Gray) Maurice A. Knight Co. (S)	P^{32}		7.2	.004	4.8	3.2	1.6
	Ba^{140}	6	6.7	.007	4.5	3.4	1.1
	I^{131}		4.0	.004	1.6	1.5	.1

Material and Manufacturer (Corrosion Rating)	Isotope	Gross Average	Spill Index	% Adsorbed in 1 hr.	DI_s	Step 1 DI	Step 2 DI
Pyroflex Lacquer (Black)	P^{32}		6.5	.02	4.8	3.3	1.5
Maurice A. Knight Co.	Ba^{140}	5	5.9	.02	4.2	3.6	.6
(S)	I^{131}		3.6	.008	1.5	1.4	.1
Silicone L3X222 (Air Dried)	P^{32}		7.1	.006	4.9	4.1	.8
Midland Ind. Co.	Ba^{140}	7	8.2	.004	5.8	4.7	1.1
(S)	I^{131}		5.6	.008	3.5	3.1	.4
Special Coating #1	P^{32}		8.0	.006	5.8	4.1	1.7
Patterson Sargent Co.	Ba^{140}	7	7.8	.004	5.4	3.7	.17
(A.S.**)	I^{131}		4.2	.008	2.1	1.9	.2
Special Coating #2	P^{32}		7.0	.01	5.0	3.9	1.1
Patterson Sargent Co.	Ba^{140}	5	6.1	.006	3.9	3.4	.5
(A.S.)	I^{131}		2.8	.04	1.4	1.0	.4
Penkote	P^{32}		.1	3.70	.6	.6	.03
Peninsular Chem. Prod. Co.	Ba^{140}	1	1.4	.2	.7	.7	.04
(S)	I^{131}		1.0	.3	.5	.5	.02
Phenoplast	P^{32}		4.0	.3	3.5	3.3	.2
Phenoplast Corporation	Ba^{140}	4	5.1	.06	3.9	3.2	.7
(A.S.)	I^{131}		4.1	.005	1.8	1.7	.1
Lead Paste and Vehicle	P^{32}		4.0	.3	3.5	3.2	.3
Pittsburgh Plate Glass Co.	Ba^{140}	3	3.2	.06	2.0	1.8	.2
(A.S.**)	I^{131}		1.5	.4	1.1	1.1	.01
White Gloss Enamel	P^{32}		4.0	.05	2.7	2.6	.1
Pratt & Lambert	Ba^{140}	4	4.2	.04	2.8	2.6	.2
(AS)	I^{131}		2.3	.06	1.1	1.1	.04
White Eggshell Enamel	P^{32}		3.9	.05	2.6	2.5	.1
Pratt & Lambert	Ba^{140}	4	3.8	.07	2.6	2.6	.02
(AS)	I^{131}		2.7	.02	1.0	1.0	.03
Proxcote 19-70-3 (Clear)	P^{32}		6.7	.06	5.5	3.6	1.9
Proxylin Products	Ba^{140}	5	6.4	.06	5.2	3.9	1.3
(S)	I^{131}		3.1	.09	2.0	1.9	.1
Prufcoat (Gray)	P^{32}		5.1	.02	3.4	3.4	.03
Prufcoat Laboratories, Inc.	Ba^{140}	5	5.1	.03	3.6	3.5	.1
(S)	I^{131}		4.0	.004	1.6	1.5	.1
Lin-X Varnish	P^{32}		5.4	.02	3.7	3.6	.1
Sherwin-Williams Co.	Ba^{140}	5	5.5	.03	4.0	3.8	.2
(AS)	I^{131}		3.2	.03	1.7	1.6	.1

Material and Manufacturer (Corrosion Rating)	Isotope	Gross Average	Spill Index	% Adsorbed in 1 hr.	DI_s	Step 1 DI	Step 2 DI
Koroseal - Tile Flooring*	P^{32}		2.2	2.4	2.5	2.3	.2
Sloane-Blabon	Ba^{140}	3	3.0	.4	2.6	2.1	.5
(S)	I^{131}		3.0	.04	1.6	1.3	.3
Flooring Sample 386A*	P^{32}		3.8	.5	3.5	3.4	.1
Sloane-Blabon	Ba^{140}	3	3.3	.08	2.2	2.0	.2
(S)	I^{131}		1.6	.08	.5	.5	.02
Flooring Sample 386B*	P^{32}		3.6	.3	3.1	2.9	.2
Sloane-Blabon	Ba^{140}	3	4.4	.1	3.4	2.0	1.4
(AS)	I^{131}		1.9	.1	.9	.7	.2
Flooring Sample 386C*	P^{32}		3.7	.5	3.4	3.2	.2
Sloane-Blabon	Ba^{140}	3	3.1	.4	2.7	1.9	.8
(S)	I^{131}		1.9	.07	.7	.7	.02
Flooring Sample 386D*	P^{32}		5.6	.08	4.5	3.6	.9
Sloane-Blabon	Ba^{140}	5	5.7	.07	4.5	3.4	.1
(E)	I^{131}		3.4	.005	1.1	1.0	.1
Flooring Sample 386E*	P^{32}		2.9	.6	2.7	2.6	.1
Sloane-Blabon	Ba^{140}	4	5.0	.1	4.0	2.3	1.7
(E)	I^{131}		3.4	.007	1.2	1.0	.2
Black Plasticol (Baked)	P^{32}		3.4	1.1	3.4	2.7	.7
Stanley Chem.	Ba^{140}	3	2.5	1.4	2.5	1.9	.6
(F)	I^{131}		2.1	.2	1.4	.3	1.1
Duralon #35	P^{32}		5.7	.05	4.4	3.8	.6
U. S. Stoneware Co.	Ba^{140}	5	4.0	1.7	4.3	3.5	.8
(E)	I^{131}		4.0	.1	3.0	2.1	.9
B-121 Unichrome (Clear)	P^{32}		6.3	.05	5.0	3.5	1.5
United Chromium	Ba^{140}	6	7.3	.02	5.6	3.8	1.8
(F)	I^{131}		4.3	.004	1.9	1.9	.04
Ucilon 451	P^{32}		3.9	.2	3.2	2.8	.4
Dull Aluminum, United Chrom.	Ba^{140}	4	5.2	.005	2.9	2.6	.3
(F)	I^{131}		3.6	.008	1.5	1.0	.5
B 124-1 Unichrom (Clear)	P^{32}		3.5	.04	2.1	1.9	.2
Baked, United Chromium	Ba^{140}	3	3.4	.03	1.9	1.8	.1
(AS)	I^{131}		1.8	.08	.7	.6	.1
Ucilon 452 (Gray)	P^{32}		3.6	.2	2.9	2.7	.2
United Chromium	Ba^{140}	4	3.7	.06	2.5	2.3	.2
(S**)	I^{131}		3.6	.02	1.9	1.7	.2
Ucilon 400-9 (White)	P^{32}		7.0	.002	4.3	3.4	.9
United Chromium	Ba^{140}	6	6.4	.04	5.0	3.6	1.4
(S)	I^{131}		4.1	.008	2.0	1.9	.1
Ucilon 1601 (Aluminum)	P^{32}		5.8	.03	4.3	3.2	1.1
United Chromium	Ba^{140}	5	6.1	.03	4.6	3.9	.7
(F)	I^{131}		3.4	.02	1.7	1.6	.1

TABLE II

SUSCEPTIBILITY OF VARIOUS

STRUCTURAL MATERIALS, TAPES AND STRIP COATS

Material and Manufacturer (Corrosion Rating)	Percent Adsorbed in One Hour		
	P^{32}	Ba^{140}	I^{131}
Liquid S.C. 553-45A Amer. Resinous Chem. Corp. (S)	0.1	0.3	0.03
Brevon-Black S.C. Atlas Powder Company (S)	0.001	0.007	0.004
Polyken Tape* Bauer and Black (S)	0.08	0.05	0.07
Bisonite #751 - White S.C. Bisonite Company (S**)	0.009	0.03	0.01
Concrete*- Special Floor Sample Carbide & Carbon, ORNL	95.4	90.3	20.2
Geon Latex 31X B. F. Goodrich (F)	21.0	21.0	6.0
Cocoon, S.C. Hollingshead Corp. (S)	0.4	0.3	4.7
O. D. #68 Tape* Industrial Tape Corp. (AS**)	9.9	43.1	41.1
Jonflex #66 Tape* Industrial Tape Corp. (AS)	0.5	18.0	0.2
Acetate Film Tape* Industrial Tape Corp. (F)	0.1	0.1	0.01

Material and Manufacturer (Corrosion Rating)	Percent Adsorbed in One Hour		
	P^{32}	Ba^{140}	I^{131}
Copeel Liquid Plastic Maas & Waldstein Company (S)	0.001	0.03	0.2
Mica S.C. - Blue Midland Ind. Finishes Co. (S)	0.03	0.04	0.03
Research Sample #J-653 (S.C.) Monsanto Chem. Company (E)	0.07	0.4	0.3
Spraylat S.C. - 1054 Spraylat Corporation (AS**)	0.1	0.3	0.3
Plywood* U. S. Plywood Company	48.0	82.0	41.0
Tygofilm - Clear S.C. U. S. Stoneware Company (S)	0.004	0.008	0.02
Aluminum*	0.5	0.04	0.05
Structural Steel*	76.6	9.3	0.1
Transite*	95.0	98.0	9.7

TABLE V

CORROSION TESTS

Material and Manufacturer	3 M HNO_3 Attacked	3 M HNO_3 Time-Hrs.	3 M HNO_3 Rating	3 M NAOH Attacked	3 M NAOH Time-Hrs.	3 M NAOH Rating	3 M HCl Attacked	3 M HCl Time-Hrs.	3 M HCl Rating	3 M H_2SO_4 Attacked	3 M H_2SO_4 Time-Hrs.	3 M H_2SO_4 Rating	Hexone Attacked	Hexone Time-Mins.	Hexone Rating
615 Rubalt Alfred Hague & Company	Y	5	P	Y	0.3	P	Y	20	P	Y	20	P	Y	1	P
Amercoat #55 Amer. Pipe & Const. Co.	N	168	E	N	168	E	N	168	E	N	336	E	Y	5	P
Amercoat #44 Amer. Pipe & Const. Co.	N	168	E	N	168	E	N	168	E	N	336	E	Y	3	P
Amercoat #31 Amer. Pipe & Const. Co.	N	168	E	N	168	E	N	168	E	N	336	E	Y	1	P
Liquid Strip 553-45A Amer. Resinous Chem. Co.	Y	142	G	Y	120	G	N	168	E	N	336	E	Y	1	P
Asphalt Tile Armstrong Cork Co.	Y	42	P	Y	48	P	Y	24	P	Y	24	P	Y	1	P
Duranite H (White) Atlas Powder Co.	Y	44	P	Y	18	P	N	168	E	Y	120	G	Y	1	P
Brevon 536-2-353 (S.C.) Atlas Powder Company	N	168	E	N	168	E	N	168	E	N	336	E	Y	1	P
20 BK Varnish Barrett Varnish Company	N	168	E	Y	18	P	N	168	E	N	336	E	Y	1	P
Polyken Tape Bauer and Black Company	N	168	E	Y	148	G	N	168	E	N	168	E	Y	240	P
Gray M-101 Bisonite Company	N	168	E	N	168	E	N	168	E	N	336	E	Y	1	P
Bisonite 751 (S.C.) Bisonite Company	Y	48	P	Y	138	G	N	168	E	Y	310	G	Y	1	P

Material and Manufacturer	Chemical Tests														
	3 M HNO_3			3 M NAOH			3 M HCl			3 M H_2SO_4			Hexone		
	Attacked	Time-Hrs.	Rating	Attacked	Time-Hrs.	Rating	Attacked	Time-Hrs.	Rating	Attacked	Time-Hrs.	Rating	Attacked	Time-Mins.	Rating
Fluorothene Carbide & Carbon Co.	N	168	E	N	168	E	N	168	E	N	168	E	N	168 hrs.	E
Plastic Coating #541 Corrosite Corporation	Y	72	M	Y	17	P	N	168	E	N	336	E	Y	3	P
Plastic Coating (Gray) Corrosite Corporation	N	168	E	N	168	E	N	168	E	N	336	E	Y	1	P
Plastic Coating #8228 Corrosite Corporation	N	168	E	N	168	E	N	168	E	N	336	E	Y	1	P
Plastic Coating (Al.) Corrosite Corporation	Y	20	P	Y	0.3	P	Y	20	P	Y	20	P	Y	1	P
Devon Resin K 5925 Devoe and Reynolds Co.	N	168	E	N	168	E	N	168	E	N	336	E	Y	24 hrs.	G
Polythene Dow Chemical Company	N	168	E	N	168	E	N	168	E	N	168	E	N	168 hrs.	E
Shell Enamel (Baked) DuPont Corporation	Y	120	G	Y	0.08	P	Y	140	G	Y	72	M	N	168 hrs.	E
Shellstone E. H. Sheldon Company	N	168	E	N	168	E	N	168	E	N	168	E	N	168 hrs.	E
Supernite Varnish The Garland Company	N	168	E	Y	17	P	N	168	E	N	336	E	Y	1	P
Acanal (White) The Garland Company	N	168	E	N	168	E	N	168	E	N	336	E	Y	1	P
Textolite General Electric Company	N	168	E	N	168	E	N	168	E	N	168	E	N	168 hrs.	E
Pli-Namel 815 The Glidden Company	N	168	E	Y	0.5	P	N	168	E	N	336	E	Y	2	P
Black Chem. Resistant #1 The Glidden Company	N	168	E	Y	0.3	P	N	168	E	N	336	E	Y	1	P

Material and Manufacturer	3 M HNO_3			3 M NAOH			3 M HCl			3 M H_2SO_4			Hexone		
	Attacked	Time-Hrs.	Rating	Attacked	Time-Hrs.	Rating	Attacked	Time-Hrs.	Rating	Attacked	Time-Hrs.	Rating	Attacked	Time-Mins.	Rating
Black Chem. Resistant #2 The Glidden Company	Y	120	G	Y	0.2	P	Y	140	G	N	336	E	Y	1	P
Black Chem. Resistant #3 The Glidden Company	Y	48	P	Y	0.2	P	N	168	E	N	336	E	Y	2	P
Methacrylate (White) The Glidden Company	N	168	E	N	168	E	N	168	E	N	336	E	Y	1	P
Alkyd (White) The Glidden Company	N	24	P	Y	0.1	P	N	168	E	N	336	E	Y	1	P
Vinyl (White) The Glidden Company	N	168	E	N	168	E	N	168	E	N	336	E	Y	1	P
Rubber Paint (White) The Glidden Company	Y	24	P	N	168	E	N	168	E	N	336	E	Y	1	P
Chlorinated Rubber (Gray) The Glidden Company	N	168	E	Y	0.9	P	N	168	E	N	336	E	Y	5	P
Geon Latex 31X (S.C.) B. F. Goodrich Chem. Co.	Y	48	P	Y	18	P	N	168	E	Y	22	P	Y	1	P
Vinyl Flooring #3511 Goodyear Rubber Company	N	168	E	Y	138	G	N	168	E	N	168	E	Y	10	P
J 241B (Gray) Gordon-Lacey Company	Y	48	P	Y	18	P	N	168	E	N	336	E	Y	1	P
J 211E (White) Gordon-Lacey Chem. Co.	N	168	E	N	168	E	N	168	E	N	336	E	Y	1	P
A 248B (Clear) Gordon-Lacey Chem. Co.	N	168	E	N	168	E	N	168	E	N	336	E	Y	1	P
J 220 F Gordon-Lacey Chem. Co.	N	168	E	N	168	E	N	168	E	N	336	E	Y	1	P
A 89A (Black) Gordon-Lacey Chem. Co.	N	168	E	N	168	E	N	168	E	N	336	E	Y	1	P
Cocoon (S.C) R.M. Hollingshead Corp.	N	168	E	N	168	E	N	168	E	N	336	E	Y	1	P
Jonflex Tape Industrial Tape Corp.	N	168	E	Y	0.5	P	N	168	E	N	168	E	Y	1	P

Material and Manufacturer	Chemical Tests: 3 M HNO_3			3 M NAOH			3 M HCl			3 M H_2SO_4			Hexone		
	Attacked	Time-Hrs.	Rating	Attacked	Time-Hrs.	Rating	Attacked	Time-Hrs.	Rating	Attacked	Time-Hrs.	Rating	Attacked	Time-Mins.	Rating
Acetate Film Tape Industrial Tape Corp.	Y	18	P	Y	20	P	Y	140	G	Y	20	P	Y	240	P
O.D. #68 Tape Industrial Tape Corp.	Y	1	P	Y	0.16	P	N	168	E	Y	140	G	Y	1	P
Rigortex 2202 (Clear) Inertol Company	Y	72	M	Y	40	P	N	168	E	N	336	E	Y	1	P
Silicone 60.9 (Baked) Interchemical Corp.	Y	2	P	Y	4	P	Y	4	P	Y	1.5	P	Y	1	P
Silicone 575 (Baked) Interchemical Corp.	Y	120	G	Y	0.16	P	Y	140	G	Y	140	G	Y	1	P
Silicone 583 (Baked) Interchemical Corp.	Y	120	G	Y	18	P	Y	140	G	N	168	E	Y	1	P
LC-600 (Clear) Lithgow Corporation	Y	48	P	Y	66	M	Y	130	G	N	336	E	Y	1	P
Cotoid (Gray) Lithgow Corporation	Y	24	P	Y	18	P	Y	20	P	Y	48	P	Y	1	P
White Enamel #3 M. Shiller Company	N	168	E	Y	18	P	N	168	E	N	336	E	Y	1	P
Coprene (Clear) Maas and Waldstein Co.	N	168	E	Y	18	P	N	168	E	N	336	E	Y	1	P
Copeel Liquid Plastic (S.C) Maas and Waldstein Company	N	168	E	N	168	E	N	168	E	N	336	E	Y	1	P
Permanite FAH Maurice Knight Company	Y	48	P	Y	0.3	P	Y	72	M	Y	20	P	Y	1	P
Pyroflex Lacquer (White) Maurice Knight Company	N	168	E	N	168	E	N	168	E	N	336	E	Y	1	P
Pyroflex Lacquer (Gray) Maurice Knight Company	N	168	E	N	168	E	N	168	E	N	336	E	Y	1	P

Material and Manufacturer	3 M HNO_3 Attacked	3 M HNO_3 Time-Hrs.	3 M HNO_3 Rating	3 M NAOH Attacked	3 M NAOH Time-Hrs.	3 M NAOH Rating	3 M HCl Attacked	3 M HCl Time-Hrs.	3 M HCl Rating	3 M H_2SO_4 Attacked	3 M H_2SO_4 Time-Hrs.	3 M H_2SO_4 Rating	Hexone Attacked	Hexone Time-Mins.	Hexone Rating
Pyroflex Lacquer (Black) Maurice Knight Company	N	168	E	N	168	E	N	168	E	N	336	E	Y	1	P
Silicone, L3X222 Midland Ind. Company	N	168	E	N	168	E	N	168	E	N	168	E	Y	1	P
Mica S.C. - Blue Midland Ind. Company	N	168	E	N	168	E	N	168	E	N	168	E	Y	1	P
J-653 Research Cample (S.C.) Monsanto Chem. Co.	Y	160	G	Y	96	G	N	168	E	N	336	E	Y	288 hrs.	E
Special Coating #1 The Patterson Sargent Co.	Y	72	M	Y	1.3	P	N	168	E	Y	330	G	Y	1	P
Special Coating #2 The Patterson Sargent Co.	N	168	E	Y	18	P	N	168	E	N	336	E	Y	1	P
Penkote Peninsular Chem. Prod. Co.	N	168	E	N	168	E	N	168	E	N	168	E	Y	1	P
Phenoplast Phenoplast Corporation	N	168	E	Y	0.08	P	N	168	E	N	168	E	Y	480	P
Lead Paste & Vehicle Pittsburgh Plate Glass Co.	Y	48	P	Y	1.3	P	N	168	E	N	336	E	Y	1	P
White Enamel Pratt and Lambert	N	168	E	Y	0.08	P	N	168	E	N	168	E	Y	5	P
Proxcote 19-70-3 Proxylin Products	N	168	E	N	168	E	N	168	E	N	336	E	Y	1	P
Prufcoat Prufcoat Laboratories	N	168	E	N	168	E	Y	140	G	Y	48	P	Y	1	P
Lucite Rohm and Haas Co.	N	168	E	N	168	E	N	168	E	N	168	E	Y	60	P
Lin-X Varnish Sherwin-Williams Company	N	168	E	Y	0.08	P	N	168	E	N	168	E	Y	1	P
Flooring Sample 386 A Sloane & Blabon Company	N	168	E	N	168	E	N	168	E	N	168	E	Y	180	P

Material and Manufacturer	3 M HNO_3			3 M NAOH			3 M HCl			3 M H_2SO_4			Hexone		
	Attacked	Time-Hrs.	Rating	Attacked	Time-Hrs.	Rating	Attacked	Time-Hrs.	Rating	Attacked	Time-Hrs.	Rating	Attacked	Time-Mins.	Rating
Flooring Sample 386B Sloane & Blabon Co.	N	168	E	Y	18	P	N	168	E	N	168	E	Y	180	P
Flooring Sample 386C Sloane & Blabon Co.	N	168	E	N	168	E	N	168	E	N	168	E	Y	180	P
Flooring Sample 386D Sloane & Blabon Co.	N	168	E	N	168	E	N	168	E	N	168	E	N	168 hrs.	E
Flooring Sample 386E Sloane & Blabon Co.	N	168	E	Y	138	G	N	168	E	N	168	E	N	168 hrs.	E
Koroseal Tile Flooring Sloane and Blabon Co.	N	168	E	N	168	E	N	168	E	N	168	E	Y	180	P
Spraylat (S.C.) - 1054 Spraylat Corporation	Y	120	G	Y	24	P	Y	48	P	Y	144	G	Y	24 hrs.	G
Black Plasticol 77R-88 The Stanley Corporation	Y	2	P	Y	18	P	Y	44	P	Y	20	P	Y	1	P
B-121 Unichrome United Chromium, Inc.	Y	24	P	Y	0.1	P	Y	20	P	Y	3	P	Y	1	P
Ucilon 451 United Chromium, Inc.	Y	48	P	Y	18	P	N	168	E	Y	321	G	Y	3	P
B-124-1 Unichrome United Chromium, Inc.	N	168	E	Y	0.2	P	Y	140	G	Y	142	G	N	168 hrs.	E
Ucilon 452 United Chromium, Inc.	Y	48	P	N	168	E	N	168	E	N	336	E	Y	1	P
Ucilon 400-9 United Chromium, Inc.	N	168	E	N	168	E	N	168	E	N	336	E	Y	1	P
Ucilon 1601 United Chromium, Inc.	Y	6	P	Y	0.1	P	Y	20	P	Y	20	P	Y	1	P
Duralon #35 U. S. Stoneware Co.	N	168	E	Y	148	G	N	168	E	N	168	E	N	168 hrs.	E
Tygofilm-Clear S.C. U. S. Stoneware Co.	N	168	E	N	168	E	N	168	E	N	168	E	Y	1	P

Code: Y - Yes, N - No, E - Excellent, G - Good, M - Medium, P - Poor aqueous reagents for the full week. Hexone might provide a good reagent for the final removal of contamination radioelements from the Devon resin. However, this point has not been investigated.

Twenty-eight coatings successfully withstood the aqueous reagents for a period of one week, but did not withstand the ketone. They are:

1. Amercoat #31	15. Gordon Lacy - J 220F
2. Amercoat #44	16. Gordon Lacy A 89A
3. Amercoat #55	17. Cocoon (S.C.)
4. Liquid Strip 553-45A	18. Copeel Liquid Plastic
5. Brevon 535-2-353 (S.C.)	19. Pyroflex - White
6. Bisonite M-101	20. Pyroflex - Gray
7. Corrosite Plastic - Gray	21. Pyroflex - Black
8. Corrosite Plastic - 8228	22. Silicone L3X222
9. Acanal - Gray	23. Mica (S.C.) - Blue
10. Acanal - White	24. Penkote
11. Glidden - RL 8222 Methacrylate	25. Proxcote - 19-70-3
12. Glidden - RL 8319-E Vinyl	26. Pruf Coat
13. Gordon Lacy J 211 E	27. Ucilon - 400-9
14. Gordon Lacy A 248B	28. Tygo Film - Clear (S.C.)

The remainder of the coatings failed in the presence of one or more of the aqueous reagents as well as hexone. Seven of these coatings failed all tests within 48 hours and are not considered suitable for areas where acids or organic reagents are used. These are:

1. 615 Rubalt	4. Cotoid
2. Corrosite-Aluminum	5. Black Plasticol
3. Silicone 60.9	6. Ucilon #1601
7. Unichrome B-121	

The authors recognize the fact that resistance to corrosion depends very greatly on the preparation of the coating. In preparing as many different materials as were examined for this work, it is almost inevitable that the best results for some coatings require a degree of "know how" in the details of preparation that we do not have. Therefore, it is probable that in a few instances, an apparent "failure" can be improved by applying the coating in a different way.

STANDARD DECONTAMINATION AND SUSCEPTIBILITY TESTS

Several paints which were tested are of the strippable type. These would logically be used under circumstances where reagent cleaning is not practical. Therefore, only their chemical resistance and susceptibility to contamination were tested. The results are presented in Table II. Unlike permanent surfaces, it is often desirable that these coatings hold all contaminants permanently so they will not rub off during the stripping process.

The results of the standard decontamination tests are presented in Table I. The data are presented independently for each radioelement. The first column gives the gross average of the "spill indices"[9] for all three elements. It is included only as an aid in locating the very good or very bad materials and has no precise quantitative significance - the larger the number, the better the material.

The second column gives the specific spill indices for each element.[9] If a spill occurs, and the radioactive solution is removed from the surface at once, only a portion of the radioactive atoms will remain adsorbed to the surface as contamination. Much of this contamination can be removed by subsequent reagent cleaning. The spill index evaluates a surface with respect to two criteria - susceptibility to contamination and ease of decontamination. From these two values, a single value can be obtained which will incorporate them both. It is designed to estimate the fraction of the total radioactive sample that is likely to remain tenaciously attached on the surface if a spill occurs and is cleaned up within an hour. However, this does not make a distinction as to whether an apparently good material is useful because the adsorption is low, or because a very large fraction may be removed by reagent cleaning even after the surface has dried, or both.

Therefore, the percent adsorbed in one hour is listed in the third column, and the standard decontamination index in the fourth column. These measure respectively the susceptibility of the surface to contamination, and its ease of decontamination after drying. Since the cleaning procedure is done in two steps, the results for each step independently are shown in the last two columns.

The authors' primary objective, which is to prepare standard tables from which materials suitable for different purposes may be selected, is fulfilled by the tables themselves. Therefore, only a few points of general interest will be discussed specifically.

Point 1: The susceptibility and decontamination properties of various types of resins and plastics showed no consistency corresponding to their chemical composition, i.e., vinyls, methyl-methacrylates, furfuraldehydes, phenolformaldehydes, etc. A much more detailed knowledge of the chemical composition of fillers, solvents, plasticizers, etc., used by each producer would be necessary before any correlation on this basis could be attempted.

Point 2: The combination of the contaminating conditions, the surface material and the cleaning reagent constitute a system of three interdependent variables which leads to a high degree of specificity in cleaning efficiency. Therefore, extrapolations to new situations is extremely uncertain. It is difficult, if not impossible, to predict what will happen.

Point 3: Since porsity and roughness were minimized in the selection of the materials, a so-called good surface could be correlated more directly with its water repellency than with any other one property. For example, the silicones, as a group, stand out because of their uniformly high spill index. A glance at the tables shows that most of this comes from tbeir uniformly low adsorption values.

Point 4: The rather uniform pattern obtained with iodine is interpreted to mean that the I^{131} is adsorbed very slowly as compared to Ba^{140} and P^{32}, but once attached to the surface it becomes very difficult to remove. This behavior is consistent with the fact that most of these materials contain double bonds with which iodine can react irreversibly as it becomes oxidized by the air. Therefore, the use of plastics and paints with I^{131} can be expected to lead to some difficulties.

Point 5: The results obtained on floor materials which have been selected in the past because of their outstanding abrasion and chemical resistance were uniformly poor, showing that reagent cleaning has little chance of success in their maintenance. (See asphalt tile, Penkote). There is ample experience to prove that this conclusion is correct. However, other materials which have not yet been extensively used in radiochemical facilities show considerable promise since, on the basis of our results, they should compete favorably[10] with some types of stainless steel, when judged only on their decontamination properties. (See Duralon 35 and Sloane Blabon Flooring Sample 386D)

Point 6: Several of the materials examined have been shown to be basically superior in decontaminating properties to glass, lead or stainless steel when used with P^{32} or Ba^{140}. Many more are just as good or almost as good.

Point 7: By comparison with the spill indices and standard decontamination indices that should be used for different activity levels, it is concluded that a very wide range of plastics and resins can be used efficiently in laboratories using 1 mc. or less activity in the total sample. A smaller number are basically capable of efficient use up to approximately 100 mc. The authors consider that efficient routine use depends on one's ability to reduce a surface contaminant to a level near "tolerance" by reagent methods without resorting to surface erosion.

A smooth, homogeneous material from which the superficial layers can be dissolved by almost successive monomolecular layers without significant penetration of the solvent makes it possible to clean even the surface-bound contaminants rather efficiently by reagent methods. If the right solvent could be found for basically unsuitable materials such as asphalt tile, Penkote, etc., their useful range could be graded upward markedly. Further developments along these lines should push the range of efficient use into the low curie region.

THE USE OF DETERGENTS

The preliminary studies reported elsewhere (1) demonstrated that other reagents were just as effective as the standard reagents for removing a particular element from a particular surface. Therefore, a preliminary study of the decontamination properties of detergents has been made.

Since lucite was readily available and had proved to be a good material from the standpoint of decontamination, under the standard conditions, the ability of several different classes of detergents to remove P^{32} and Ba^{140} after air drying on lucite was studied. The results are presented in Table III showing the decontamination index for the detergent, the separate indices at each step in the procedure, and the comparative results with the standard decontamination index which was obtained by the use of the standard reagent.

The decontamination efficiency of the detergent as compared to that of the standard reagent is shown in the last column. Since the efficiency of each reagent is reported numerically in the logarithmic form, the relative efficiencies are measured by subtracting the decontamination index of the standard reagent (DI_s) from that of the detergent (DI_{Det}). A positive value indicates that the detergent was a better cleaning agent than the standard reagent, while a negative value indicates that it was a poorer reagent. When the difference falls between + 0.5 and - 0.5, the two are considered to be

TABLE III

DECONTAMINATION OF LUCITE WITH VARIOUS DETERGENTS AND WETTING AGENTS

Cleaning Reagent & Manufacturer	Isotope	Total DI for Det.	Step #1 DI	Step #2 DI	$DI_{Det} - DI_s$
0.1% Nytron	P^{32}	5.0	2.9	2.1	- 2.1
Allied Chem. & Dye Co.	Ba^{140}	4.0	0.5	3.5	- 0.7
	I^{131}	2.6	2.4	0.2	- 0.3
1% Nytron	P^{32}	5.2	3.0	2.2	- 1.9
Allied Chem. & Dye Co.	Ba^{140}	3.6	0.4	3.2	- 1.1
	I^{131}	2.8	2.5	0.3	- 0.1
1% Sequestrene A.A.	P^{32}	6.3	3.6	2.7	- 0.8
Alrose Chem. Company	Ba^{140}	4.4	1.6	2.8	- 0.4
1% Amine O	P^{32}	6.1	4.0	2.1	- 1.0
Alrose Chem. Company	Ba^{140}	4.9	1.8	3.1	+ 0.2
1% Rynsynol	P^{32}	4.8	2.7	2.1	- 2.3
Alrose Chem. Company	Ba^{140}	4.2	1.2	3.0	- 0.7
1% Tergitol WA #4	P^{32}	6.9	4.1	2.8	- 0.2
Carbide & Carbon Chem. Corp.	Ba^{140}	4.1	1.9	2.2	- 0.6
1% Solvadine EO	P^{32}	5.7	3.5	2.2	- 1.4
Ciba Company	Ba^{140}	3.6	0.9	2.7	- 1.1
1% Product QB	P^{32}	4.4	2.6	1.8	- 2.7
DuPont Corporation	Ba^{140}	4.2	1.7	2.5	- 0.7
10% CMS (DuPont Corp.)	P^{32}	7.2	4.1	3.1	+ 0.1
and 1% S-189	Ba^{140}	3.3	2.1	1.2	- 1.1
1% S-189	P^{32}	4.4	2.5	1.9	- 2.7
Jacques Wolfe & Co.	Ba^{140}	2.7	1.0	1.7	- 2.0
1% B.T.C.	P^{32}	4.7	2.7	2.0	- 2.4
Onyx Oil & Chem. Co.	Ba^{140}	3.4	1.1	2.3	- 1.3
1% Phil-O-Sol	P^{32}	5.3	2.7	2.6	- 1.8
Onyx Oil & Chem. Co.	Ba^{140}	3.4	.8	2.6	- 1.3
1% D2-389	P^{32}	4.4	2.6	1.8	- 2.7
Rohm and Haas Company	Ba^{140}	3.6	1.2	2.4	- 1.1

Table III

Cleaning Reagent & Manufacturer	Isotope	Total DI for Det.	Step #1 DI	Step #2 DI	$DI_{Det} - DI_s$
1% Triton 720	P^{32}	5.0	2.9	2.1	- 2.1
Rohm and Haas Company	Ba^{140}	3.1	.8	2.3	- 1.6
1% Trinton 770	P^{32}	5.0	2.5	2.5	- 2.1
Rohm and Haas Company	Ba^{140}	4.0	.7	3.3	- 0.7
1% Mulsor 224	P^{32}	5.4	2.7	2.7	- 1.7
Synthetic Chem. Inc.	Ba^{140}	4.0	1.1	2.9	- 0.7
	I^{131}	3.1	2.8	.3	+ 0.2
1% Mulsor 224	P^{32}	4.9	3.2	1.7	- 2.2
and 10% C.M.S.	Ba^{140}	3.7	2.0	1.7	- 1.0
	I^{131}	3.0	2.7	.3	+ 0.1

essentially equal in efficiency.

The results show that the only two detergents (Nytron and Mulsor) tried with I^{131} were just as good as 56%-HI in removing the contaminant. Two reagents (Tergitol WA 4, and S-189-Jacques-Wolfe Co., plus DuPont CMS protective colloid) were just as effective as 3N HNO_3-3N H_3PO_4 in removing P^{32}. Several were just as good or almost as good as 6N HNO_3 in removing Ba^{140}.

The protective colloid (CMS-DuPont) was tried in conjunction with an anionic detergent (S-189 Jacques-Wolfe Co.) and with a nonionic detergent on both lucite and glass. It caused a marked improvement in the action of the anionic product, but had no apparent effect on the nonionic product. This observation is consistent with the anticipated specificity of detergent action which at present is based on the thought that the reaction of the detergent with the surface material contributes far more to its cleaning efficiency than does a reaction between the reagent and the radioelement. Additional evidence pointing in the same direction is the fact that Sequestrene A.A. which is a chelating reagent was much better for removing P^{32}, with which there should be no chemical combination, than it was for removing Ba^{140}, with which it forms a complex ion, thus displacing the Ba^{++} equilibrium toward the solution.

In the second experiment air-dried P^{32}, Ba^{140} and I^{131} were removed from a representative group of materials by Mulsor 224 which had proved to be an average detergent in the previous experiment. The results, presented in Table IV, show that Mulsor can compete with the standard reagent in only a few instances, most of these being in the removal of I^{131}. It should also be noted that on a particular material, one or another of the elements may be removed more efficiently than the others. There is no consistent relation between the indices for the different elements when one uses the same detergent for removing contamination from different surfaces.

TABLE IV

DECONTAMINATION OF SELECTED RESINS WITH MULSOR 224

Cleaning Reagent and Manufacturer	Isotope	Total DI for Det.	Step #1 DI	Step #2 DI	$DI_{Det} - DI_s$
Amercoat #31	P^{32}	3.9	2.6	1.3	- 1.2
Amer. Pipe & Constr. Co.	Ba^{140}	3.0	1.2	1.8	- 1.5
	I^{131}	2.4	2.1	0.3	- 0.8
Asphalt Tile Flooring	P^{32}	0.5	0.3	0.2	- 1.9
Armstrong Cork Company	Ba^{140}	0.7	0.4	0.3	- 2.2
	I^{131}	0.4	0.3	0.1	- 2.4
Polythene	P^{32}	4.0	1.9	2.1	- 1.4
DuPont Corporation	Ba^{140}	3.1	0.5	2.6	- 2.9
	I^{131}	1.8	1.6	0.2	- 1.4
Shell Enamel	P^{32}	4.7	3.4	1.3	- 0.2
DuPont Corporation	Ba^{140}	4.2	0.7	3.5	- 1.5
	I^{131}	1.8	1.6	0.2	- 0.2
A-248-B	P^{32}	4.7	3.3	1.4	- 0.2
Gordon Lacy Company	Ba^{140}	3.7	1.8	1.9	- 1.0
	I^{131}	1.7	1.6	0.1	- 0.5
Silicone #583	P^{32}	3.7	3.1	0.6	- 2.8
Interchem. Corporation	Ba^{140}	3.4	1.4	2.0	- 2.8
	I^{131}	1.9	1.8	0.1	- 0.8
Koroseal Tile Flooring	P^{32}	1.2	0.4	0.8	- 1.3
Sloane Blabon Company	Ba^{140}	0.9	0.3	0.6	- 1.7
	I^{131}	0.4	0.4	0.01	- 1.2

The same observation was made with respect to the removal of these three elements from glass, stainless steel and lead, again pointing up the fact that reagent cleaning involves the interaction of at lease three major variables - the surface, the radioelement and the cleaning reagent. The development of detergents which have outstanding cleaning properties promises to be a matter of fitting the reagent to a specific job - at least until the mechanism of the action is better understood.

Despite the unfavorable comparison of many detergents with the standard reagent, the first experiment demonstrated that a detergent may be found that is just as good as the standard reagent for removing a particular element from a particular surface material. Also, a large number of cleaning problems exist for which a decontamination index of 3 or 4 is quite adequate, and Mulsor, an "average detergent" when used with lucite, gave an index of this magnitude on several of the materials.

It should be noted also that Mulsor on asphalt tile and Koroseal tile was virtually useless. If these materials are selected for use in a radiochemical laboratory to take advantage of their proven wearing qualities, one should be prepared to adopt a maintenance policy of replacing the contaminated areas.

SUMMARY

The corrosion resistance and decontaminating properties of several available paints, plastics and resins have been studied under standardized conditions. It is concluded that some of these may be used to advantage in place of glass, stainless steel or lead for many common functions, and that they may often be cleaned by mild reagents, such as detergents. The combination of the contaminating conditions, the surface material, and the cleaning reagent are interdependent variables which leads to a high degree of specificity in cleaning efficiency.

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LITERATURE CITED

(1) Tompkins, P. C. and Bizzell, O. M. - In Press.

(2) Radioisotope Catalog, Sept. (1947) - Isotopes Division (A.E.C.).

FOOTNOTES

1. Based on work done in the Biology Division, Oak Ridge National Laboratory under Contract No. W-7405-Eng-26 for the Atomic Energy Commission.

2. Present address: Naval Radiological Defense Laboratory, San Francisco, California.

3. Isotopes Division, Atomic Energy Commission, Oak Ridge, Tennessee.

4. Technical Division, Oak Ridge National Laboratories, Oak Ridge, Tennessee.

5. The inclusion or exclusion of specific materials in these tests does not necessarily constitute an indorsement or rejection of a product.

6. The Decontamination Index = $\text{Log}\left(\frac{\text{Activity on Surface before Cleaning}}{\text{Activity on Surface after Cleaning}}\right)$

7. No Isotopic carrier added deliberately during production. The total solids were of the general order of 1 mg/25 ml.

8. The authors are particularly indebted to Arthur D. Little, Inc. for making available to them some information obtained during their extensive studies of materials to be used in the construction of some of the new A.E.C. facilities.

9. Spill Index = $\text{Log}\left(\frac{\text{Act. on Surface after Cleaning}}{\text{Total Activity of Sample}}\right) = (\text{Log \% of Ads} - DI_s)$

10. The material should have a spill index of 7 or higher and a DI_s of 6 or higher to be considered markedly superior. It needs a spill index of 5-6 and a DI_s of 4-5 to be considered comparable.

11. Resistance to corrosion depends very greatly on the preparation of the coating. It is probable that in a few instances better resistance could be shown by applying the coating in a different way.

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